

# Handheld Computers as Educational Tools

# 1

**E**ducational tools over the years have ranged from pieces of chalk and slate to pencil and paper, from fountain pens to ballpoint pens. Similarly, materials changed from primers to full sets of texts. As schools and communities built libraries, students were assigned research topics and referred to bound encyclopedias, books, and magazine articles to gather facts and figures. With the arrival of the ditto machine and later the photocopier, teachers reproduced worksheets to provide drill activities and question sheets for practicing and processing classroom learning. The invention of the overhead projector provided a means for making learning more visual and colorful than the old blackboard and further reinforced the role of the teacher as the expert in the classroom. The tools did little to reconstruct the fundamental notion of teacher as imparter of knowledge. Tools and materials evolved, but the classroom roles remained constant until recently. The late 20th century saw the beginning of a transformation in the teaching and in the learning relationships. Frequently, students whose families invested early in home technology at the beginning of the Internet wave would come to school the day after the teacher introduced a new topic or unit and offer, "I found something on the Internet about what you told us yesterday. Would you like me to bring it in?" Then the student would enthusiastically share with the class and teacher the additional background the student had found on the topic. The teacher or a classmate might then ask the student a question about the material. This was the lightning bolt moment when a new kind of electricity began to recharge classrooms and reconfigure learning relationships.

Once learning started to move across the bridge to technology, including Internet access, more changes were bound to come. Unfortunately, the promise often outstripped reality, for a variety of reasons both technological and human. By the close of the 20th century, adventuresome teachers in well-funded schools were incorporating technology directly into learning as they sent students to

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computers for information, powerful processing tools and simulations, and new stimuli for the teaching of critical thinking and problem solving. Still, the hardware and infrastructure costs, as well as the logistics of this kind of learning, challenged many schools and teachers. One of the greatest impediments to full use was that unlike workplace and other similar settings, where it was assumed that no one could accomplish work goals without an individual computer, in schools not every desk had a computer on it for ready individual use. In fact, usage was both limited and complicated. The reason for this was largely but not entirely expense.

We are at a new crossroads, thanks to new technology that scales down the equipment in both cost and size without a substantial sacrifice of power. For the cost of 3 classroom computers, it is now possible to purchase 10 to 12 handheld computers. Putting these new portables in the hands of all students has the capacity to change the way we teach and learn. Teachers will guide student learning experiences and, particularly in our standards-based environment, will align learning experiences to meet those standards. What the new technology allows is for students to meet those standards in individualized ways, collect personally meaningful data, and use it to gain understanding of a larger inquiry process that begins to replicate the thinking and learning processes of real work or advanced study. Students and teachers can share data together and create larger data pools from which to build the skills of deep analysis and further inquiry. Students are likely to ask teachers bigger questions, and teachers are as likely to provide some necessary information and then turn those questions back to students with further questions and suggestions for further inquiry or analysis. The new tools can be used in ways that hugely expand what we think of as the learning space. Teachers and students can develop more collaborative ways of teaching and learning than ever before. Handheld computers can place the student at the center of learning; handheld computers offer such promise.

Both hardware and software evolve overnight, and new tools as well as new capacity for the last “new” tools come to the marketplace every day. One of the most promising technologies for education likely will be cell phones, which are already incorporating communication, Internet research, applications, and photographic capacity. For purposes of this book, we will think of handhelds as a combination of technology that offers this future potential. Specific activities and instructions are offered for these handhelds. As equipment changes, these processes will become models that migrate to new equipment.

### FIVE BIG REASONS FOR HANDHELDS IN SCHOOLS

When asked recently what are the top five reasons for using handheld computers in schools, my response was immediate: They provide *equitable access* to

*digital technologies* for all children, they are *intuitive* and easy-to-use learning tools, they are the much-needed future *ubiquitous portable* devices, they promote *collaboration* among students and teachers, and they make it possible for meaningful and *seamless interactions* between multiple applications and peripheral devices.

To make changes in how students are taught and how they learn, teachers need to be prepared to use new tools and to change their roles in the classroom (Darling-Hammond, 1997):

If teachers are to prepare an ever more diverse group of students for much more challenging work—for framing problems; finding, integrating and synthesizing information; creating new solutions; learning on their own; and working cooperatively—they will need substantially more knowledge and radically different skills than most now have and most schools of education now develop. (p. 154)

Teachers in the field will need initial courage to open the path to these new kinds of learning. I hope that this book will offer support for that journey for both classroom teachers and teachers in training.

Because many new technologies are interactive, it is easier to create environments in which students can learn by doing, receive formative feedback, and continually refine their understanding and build new knowledge. Technology can help to create an active environment in which students not only solve problems but also find their own problems (Bransford, Brown, & Cocking, 1999). When used in a context of student inquiry and critical analysis of a vast amount of information simultaneously, handheld technologies offer a promise to provide the computational power and communication channels to empower the individual learner in and outside school.

### **Equitable Access to Digital Technologies**

All students need to have the benefits of the digital technologies. They all must have access to information, computation, and communications tools that will help them in the future workforce. Keep in mind that these educational benefits are what are important and that the access to the technology is only a means to an end. Today, few students, especially the disadvantaged, have adequate exposure to computers to become comfortable with them as a personal tool. Institutional school computers by nature limit familiarity by restricting use. There are too few computers for the numbers of students, computers are located in overcrowded and overbooked computer labs, and computers and servers do not allow access to stored work outside the school. Research shows that giving students a personal learning device can make learning more

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meaningful to them. Using handheld computers makes it possible for students to take ownership of their work products and learning. With ongoing access to a handheld computer, students become more autonomous and self-directed in their learning (SRI International & Palm, Inc., 2002). According to the National Center for Educational Statistics (NCES), the ratio of students to computers in elementary and secondary schools in the United States is eight students to one computer in cities and five students to one computer in rural settings (NCES, 2000). For those limited classrooms equipped with between 3 and 10 computers, a student still needs to wait in line behind other classmates to use the technology. The technology becomes an intrusion, not a natural extension of the learning environment.

A handheld computer offers automatic storage, an intuitive pen-based graphical interface, and quick and easy communication with other handheld or desktop computers at any location, in or outside school. To provide digital personal tools that will bridge the digital divide, students must have access where and when they need it. The low costs of handheld computers make it more possible for schools to provide equitable access, leaving no child behind.

##### **Intuitiveness**

It is easy to forget that student achievement in school depends in part on what happens outside school. Modern technologies can help make connections between students' in-school and out-of-school activities (Bransford et al., 1999). The students of today grew up using GameBoys™ and video games. They easily manipulate small graphically designed screens to complete tasks. They insert game modules and other peripheral devices such as cameras to create their own gaming environments. Although these portable gaming units are toys, they fulfill many educational needs. Similarly, student use of pagers and cell phones outside school make the new handhelds natural tools for them.

When students have shared their dreams about the design of their own personal educational handheld devices, requests have been remarkably similar, as shown by the research funded by the National Science Foundation (*DataGotchi Deep Dive*, 1998). Students want a personal device that is portable and easy to operate. It should feel like a toy, they say, yet provide the ability to input and analyze data from a wide variety of sources. Often students want the tool to be as powerful as a desktop computer, yet compact enough to wear. Finally, students want wireless connection to the Internet and to other devices.

When teachers are asked about their computing needs (*DataGotchi Deep Dive*, 1998), they focus on reliability and performance rather than size or portability. Teachers are often wary of all technology and fear that they will need elaborate skills to operate or troubleshoot problems. The teacher's ideal device would provide applications that build student inquiry-based skills and track

student progress seamlessly. Handheld computers in the classroom must provide a means to communicate and collaborate between the student and the teacher. Like students, teachers demand ease of use. Handheld computers, software, and peripherals that meet most of these needs are now available.

#### *Student Needs*

- Personal and portable device
- Ability to create, invent, and imagine
- Useful outside the classroom
- Be a tool, yet feel like a toy
- Work that can be private, shared, and/or published
- Promote reflection
- Multiple representations (e.g., graphs, tables, animations)
- Multiple inputs (e.g., touch screen, optional keyboard, voice, camera, sensor)
- Multiple outputs (e.g., Web page, paper, projection)

#### *Teacher Needs*

- Total class participation
- Ease of use
- No downtime
- Inquiry-based activities and applications
- Richer meanings of concepts and student models
- Tight coupling to curriculum and standards
- Recording of process and end product
- Evaluation of performance and response
- Reliable data transfer

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SOURCE: Adapted from *DataGotchi Deep Dive* (1998) and unpublished data collected by KidSolve™, Inc.

In the past, successful integration of technology was related to the user's comfort with the technology and its features and functions. Unlike desktop computers, the handheld computer has a remarkably short learning curve, especially for students. Because of their familiarity with gaming devices, students intuitively adopt the handheld as a personal computing device. They quickly find the stylus, tap into applications, and learn methods to enter and "beam" data between devices. Training sessions are no longer days or weeks, but can be measured in minutes. Teachers, on the other hand, take a little longer to learn the functions and are often tentative with the smaller device, but they also learn easily to work with handhelds. The reality is that the technology

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and technological savvy of this generation of students is different from that for adults. Handheld devices are part of their world already!

### Ubiquitous Portability

Students' casual and disjointed use of digital technology in education often impedes learning. They spend valuable time adjusting to different computers and applications, rather than experiencing the technology as a seamless extension of their learning environment. As students are shifted from one institutional computer to another throughout the school, they must familiarize themselves with differences between devices and applications. If the classroom is equipped with a few desktops or laptops, they must walk down the hall to a desktop computer located in a separate computer lab or wait in line. With handheld computers, students could simply reach into their backpacks or pockets whenever they need the digital tool. Future students might even *wear* such small computers!

Students' interaction with computers in a discrete lab environment, dissociated from other learning activities, is not a realistic demonstration of their future digital workplace, where computer use is encountered nearly everywhere, in jobs at every level. Portable handheld computers can be used at any location: in the school hallway, on the school bus, in the field, and at home. Through the attachment of sensors (e.g., light, pH, temperature), cameras, or GPS (global positioning system) units to portable handheld computers, the learning experiences become enhanced and more realistic to the students in and outside the classroom.

### Collaboration

Handheld computers have the capability to transmit data from device to device, either by infrared beaming or—with newer models—through radio waves. This means that data, writing, concept maps, graphs, and drawings can be exchanged digitally among the devices without wires. Infrared beaming is limited to relatively short, line-of-sight distances between one handheld computer and another, but it offers a powerful way to share information between team members. Radio transmittance enables a network that can send or receive information from multiple handheld computers, at distances of up to 30 feet. The transfer of data does not need to be restricted to other handheld computers. Other wireless devices, such as GPS units, printers, and sensors, can also transfer data to and from handheld computers.

In addition to supplementing sharing of group information among team members, infrared and wireless beaming affords the opportunity for a joint “collaborative white board” in the classroom. With classroom networks,

teachers can require students to send their ideas, solutions, or questions during the instruction, and teachers can make immediate adjustments to account for students' needs and their developing ideas in a learner-centered environment. Students can reveal important contrasts and patterns in mathematical and scientific ideas and connect the learning of each individual with the learning of the group. Teachers can provide each student with frequent, formative feedback, and the teacher receives rapid insight into the current level of understanding throughout the classroom (Roschelle, Penuel, & Abrahamson, 2003). By making it possible for students to share thoughts, predictions, and drawings, teachers can obtain immediate conceptual models from their students. By encouraging students to justify their input on a shared document, teachers can instantly poll students' understanding and adjust lessons accordingly.

Transferred information is digital information, which means that the data are searchable and can be sorted. Students can review group predictions, collaborative sketches, and laboratory results to produce a joint report of their findings. With the use of wireless networking, students also can publish their conclusions on the Web directly from their handheld computers.

### **Seamless Interactions**

But why use a technological device in the classroom that costs more than less-expensive educational tools such as paper and pencils? The answer is quite simple: Relatively low-cost handheld computers can provide additional benefits not found with paper and pencil. How they are used in schools is the determining factor when considering purchasing these devices. If the handheld computer is used to "automate" existing practices, the additional cost is not warranted. "Automating essentially means 'bolting' technology on top of current processes and procedures" (November, 2001, p. xix). If used properly, technology tools can change the focus of the classroom from teacher to student; the flow of information (from data, drawings, sensors, and pictures) also changes. Using handheld computers as an "informating" tool rather than as an automating one empowers students to solve problems. Properly designed and applied technologies can generate information as a consequence of their use. Scientific visualization provides models of how, in the course of the data collection, students can generate new views of that data and therefore support new insights. Digital applications can present teachers with new information about student understanding as students use the technologies.

In the business world, handhelds are often used as organizers and planners, but educational software is steadily increasing the capabilities of the handheld computers to help students engage in inquiry learning and problem solving. Many of the new educational applications written for handheld computers make the exchange of data between several applications possible.

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For instance, spreadsheets have been designed to accept data from sensor software. Dictionaries enable words to be transferred into writing programs. Statistical analysis software can operate on imported data from calculators and probe-based data acquisition applications. Annotated notes can be attached to digital picture albums for community or field studies. As additional memory and card slots become available, students will be able to access a vast amount of data anytime, anywhere.

### EFFECTIVE USE

Not so long ago, schools prided themselves on the presence of institutional computers, often found in computer labs. Teachers booked computer labs months in advance, and these labs were not accessible to students on demand. In some places, this mode still exists. Where it does, students have had limited access to their own work, based on the scheduling of the computer lab and the limits of the class period. Students have no hope of completing their unfinished work or retrieving their data outside school hours. With the move toward equipping classrooms with one to five desktops, the situation improved somewhat but posed its own problems associated with running two simultaneous learning paths in the classroom because universal access was not possible. Now, however, with a handheld device as a replacement for such institutional devices, all students can have computing power in their hands anytime, anywhere, and for considerably less expense than the desktop computer. On average, an adequate handheld computer with at least 8 MB of memory costs about one fifth the price of a desktop computer found in a typical computer lab, or even less. Keep in mind that this type of handheld computer is more powerful than the old Apple IIe™ and has a faster processor.

The Apple IIe™ had 64K of memory and a 1 MHz processor. A Palm™ Tungsten™ T2 has 32 MB of memory and a 200 MHz processor. The Tungsten™ T2 has approximately 128 times as much memory and 200 times the speed. This generation of Palm™ is approximately equivalent to a PowerMac 7200™. The original Palms were similar to a 1 MB Mac Classic™ (S. Bannasch, personal communication, 2003).

Designers of handheld computers originally viewed them as complements to desktop computers, not as a substitute for them. As a result, rich educational applications such as databases, spreadsheets, survey makers, word processors, and graphing applications must be designed specifically for use on the handheld device. Storage and exchange of data must be easy and reliable for large

numbers of students. Although some present applications meet these needs, as demonstrated throughout this book, further development must occur in both the handheld hardware and the accompanying software.

Successful integration challenges teachers and students to use the technology in creative and meaningful ways. Portable handheld computers are well suited for implementing active learning activities that engage students and encourage exploration and collaboration. It is imperative to think of these devices not as a solution but rather as an educational tool that plays a vital role in helping teachers alter and update the teaching style and conception of the classroom to more effectively engage students in complex meaningful learning and prepare them equitably for the demands of higher education and the world of work.

## **OVERVIEW OF THE BOOK**

This book is intended to help elementary, middle, and secondary educators to incorporate the new handhelds into classroom teaching and student learning. It is written to help teachers, school leaders, curriculum designers, technology leaders, and teacher educators in the following ways:

1. By providing teachers with concrete step-by-step examples for how to use handheld technology in their classrooms in ways that will foster critical thinking and more collaborative student-directed learning while meeting standards for content areas and technology integration.
2. By providing principals with a vision and a rationale for the use of more economical and equitable handheld computing devices in order to take teaching and learning to more engaged, collaborative, connected, and powerful levels of student learning.
3. By providing technology planners and leaders, curriculum and instruction leaders, and teacher leaders with sample lessons that they can use with teachers to scaffold their movement toward confident adoption of technology to make learning more meaningful and content more connected to real life, while aligning with content standards and technology integration requirements.

In states and districts where handhelds have been purchased for all students, this book is offered as a launching point for their meaningful incorporation. For teachers and schools that are experimenting, this book is intended as a means to create meaningful models for other educators.

Individual chapters of this book provide teachers with examples of significant and powerful tested learning activities that use handheld computers in

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and outside the classroom. Each activity comes with student instructions that allow the teacher to try the activity first. Some teachers may want to enlist one of their tech-savvy students as a consultant to test-run the activity and teach it to the teacher before the activity is introduced to the class.

Chapter 2 provides organizational and planning activities that help reveal what students are doing, thinking, and understanding.

Chapter 3 illustrates the integration of easily accessible reference materials linked to motivating and engaging applications for review and exploration of information.

Chapter 4 describes uses of the handheld computer that place students at the center of their own data gathering.

Chapter 5 presents meaningful ways to manipulate and display data to assist in thorough conceptual understanding.

Chapter 6 illustrates how students can communicate easily using a handheld computer to share ideas and collaborate on a joint project.

Chapter 7 promotes personal student evaluation, making it possible for students to support and assess their own individual learning.

Chapter 8 reviews answers to commonly asked questions about handheld computer integration that empower both teachers and students.

Each showcased activity is demonstrated with a specific application on the PalmOne™ handheld computer platform. Many applications are freeware or relatively inexpensive applications. Application suggestions for both the PalmOne™ and Pocket PC platforms are provided when available. Each activity has a suggested grade level and subject, learning outcomes and standards, possible classroom approach, and extensions for other subject areas. Each activity concludes with student processing questions, which can be used to assess student learning.

### GOING FORWARD

The new handhelds have capacities beyond even individual desk-based computers; they allow students to beam shared data to one another and continue to learn on the bus and at home. They are ideal tools for integrating problem-based learning that clusters standards across content. Used well, they support evidence-based teaching strategies, including cooperative learning and graphic organizers.

Picture again a student of 150 years ago, touching chalk to a slate. With the same stroke, a student today can graphically reorganize pages of data or open a world of information. In this sea of possibility, teachers become more important than ever as they guide students to be effective, selective, and analytical and as they help students use the new tools with purpose, toward the construction of meaning, understanding, and new knowledge.